

Chapter 1 - Introduction

Echo sounding is a technique for measuring water depths by transmitting acoustic pulses from the ocean surface and listening for their reflection (or echo) from the sea floor. This technique has been used since the early twentieth century to provide the vital depth input to charts that now map most of the world's water-covered areas. These charts have permitted ships to navigate safely through the world's oceans. In addition, information derived from echo sounding has aided in laying trans-oceanic telephone cables, exploring and drilling for off-shore oil, locating important underwater mineral deposits, and improving our understanding of the Earth's geological processes.

Until the early 1960s most depth sounding used single-beam echo sounders. These devices make a single depth measurement with each acoustic pulse (or ping) and include both wide and narrow beam systems. Relatively inexpensive wide-beam “unstabilized” sounders detect echoes within a large solid angle under a vessel and are useful for finding potential hazards to safe navigation. However, these devices are unable to provide much detailed information about the sea bottom. On the other hand, more expensive narrow-beam “stabilized” sounders are capable of providing high spatial resolution with the small solid angle encompassed by their beam, but can cover only a limited survey area with each ping. Neither system provides a method for creating detailed maps of the sea floor that minimizes ship time and is thus cost-effective. The unstabilized systems lack the necessary spatial resolution, while the stabilized systems map too little area with each ping.

In 1964, SeaBeam Instruments—at the time the Harris Anti-Submarine Warfare Division of General Instrument Corporation—patented a technique for multiple narrow-beam depth sounding. The first such systems to use this technique were built by SeaBeam for the US Navy and were known as Sonar Array Sounding Systems (SASS). SASS employed two separate sonar arrays oriented orthogonal to one another—one for transmitting and one for receiving—an arrangement called a Mills Cross Array. The arrays and the associated analog electronics provided 90 1°-wide unstabilized beams. Roll and pitch compensation produced 60 1°-wide stabilized beams, which permitted mapping a 60° “fan” of the sea floor with each ping. This system allowed survey vessels to produce high-resolution coverage of wide swaths of the ocean bottom in far less ship time than would have been required for a single-beam echo sounder, greatly reducing the costs of such mapping endeavors.

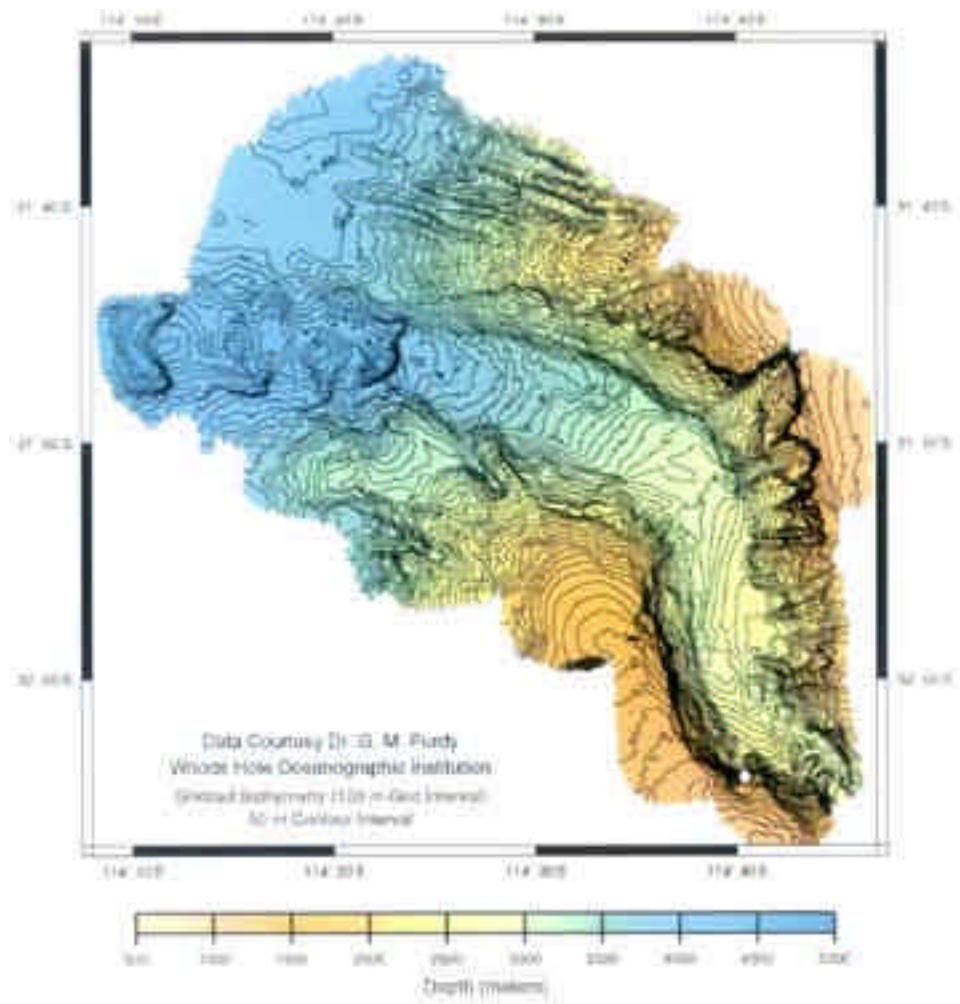


Figure Chapter 1 - -1: Contour Map of Perth Canyon

Most multibeam bathymetry systems still use the Mills Cross technique for beam forming. However, as faster computers and Large Scale Integrated (LSI) digital chips have become available, most of the signal processing, including beam forming, moved from analog signal processing into the digital (discrete) signal processing (DSP) domain using digital signal microprocessor (DSP μ P) chips. The availability of fast DSP μ Ps has also permitted the implementation of sophisticated detection algorithms. As a result, survey vessels today can do on-board real-time multibeam processing and display of bathymetry data in a manner impossible only a few years ago. Figure Chapter 1 - -1 shows a sample of a high-quality ocean floor map produced by a SEA BEAM 2100 Multibeam Survey System, the latest generation of multibeam sonar from SeaBeam Instruments.

The SEA BEAM 2100 system represents the culmination of over a third of a century of design, development, and production experience by SeaBeam Instruments in the area of multibeam bathymetric systems. With added sophistication, this latest generation multibeam sonar system has added capabilities and complexity. It is necessary to have a basic theoretical understanding of the way multibeam bathymetry systems in general, and the SEA BEAM 2100 in particular, work in order to both:

- Operate the system in a manner that maximizes coverage and data quality
- Evaluate the system performance for signs of system degradation

Organization of this Document

This manual provides a general explanation of the way a multibeam sonar system works and describes in detail the implementation of multibeam technology represented by the SEA BEAM 2100 system.

Chapter 2, “Sonar Concepts,” introduces the concepts and definitions involved in echo sounding, using a description of a simple single-beam echo sounder as an example. Characteristics of the creation and transmission of acoustic pulses in water and their echoes off the ocean bottom are discussed. This chapter also explains some of the limitations of a single-beam sonar.

Chapter 3, “Introduction to Multibeam Sonar: Projector and Hydrophone Systems,” describes the Mills Cross technique, including the processes of beam forming and beam steering and how it is applied to sonar and to the SEA BEAM 2100 in particular. The chapter discusses how systems that employ the Mills Cross technique can make up for many of the short-comings of single-beam echo sounders.

Chapter 4, “Detection Processing and Range Calculation,” describes how the SEA BEAM 2100 extracts signals and determines the location of the sea floor from multibeam echoes. The processes used for ship motion compensation and the formation of stable beams and the implementation of sound velocity profiles are discussed.

Chapter 5, “Sidescan Sonar,” discusses sea floor imaging using sidescan sonars and how the SEA BEAM 2100 can be used simultaneously as a depth-finding and sidescan sonar.

A glossary of the terminology of multibeam sonar technology is included as an appendix.

Scope of this Document

Multibeam technology involves a number of disciplines including underwater acoustics, digital signal processing, and detection theory statistics. Many excellent texts are available that provide in-depth mathematical treatment of each of these fields. The purpose of this document is not to cover all related topics in rigorous mathematical detail, but instead to present you with a simple, clear understanding of the fundamental concepts required to develop the full potential of a multibeam sonar system. Ideas are presented in a graphical and descriptive way, with minimal use of complex mathematics. Where appropriate, references to texts are provided so you can pursue topics in greater detail. While directed at users of the SEA BEAM 2100 system in particular, most of the concepts explained in this document are common to all multibeam sonars, so much of this information can be applied to any commercially available multibeam system.

